Docket No.: N.C. 82,502 PATENT APPLICATION
Inventor's Name: Donald U. Gubser and M. Ashraf Imam

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application:
Gubser et al
Parent Class - 505
Parent Group Art Unit - 3726
Parent Filed: June 18, 1997
Parent Serial No.: 08/877,880

Title of Parent: HIGH TEMPERATURE SUPERCONDUCTING CERAMIC OXIDE COMPOSITE WITH RETICULATED METAL FOAM
Commissioner of Patents and Trademarks
Washington, D.C. 20231

REQUEST TO FILE A DIVISIONAL APPLICATION UNDER 37 CFR 1.53(b)(1)

This is a request for filing a Divisional application under 37 CFR 1.53(b)(1), of pending application Serial No. 08/877,880, filed on June 18, 1997, of Donald U. Gubser and M. Ashraf Imam, for HIGH TEMPERATURE SUPERCONDUCTING CERAMIC OXIDE COMPOSITE WITH RETICULATED METAL FOAM. The attached papers are a true copy of what is shown in my records to be the above identified prior application, including the oath or declaration originally filed in the grandparent application. The copy of the papers of the prior application as filed which are attached are as follows:

11 pages of specification (excluding claims)
2 sheets of drawings
5 pages of claims
1 page of abstract
1 page of declaration and power of attorney

With respect to the prior co-pending U.S. application from which this application claims benefit under **35 USC § 120**, the inventor in this application is the same. The inventorship for all

the claims in this application is the same.

The filing fee is calculated below:

CLAIMS AS FILED IN THE PRIOR APPLICATION LESS ANY CLAIMS

CANCELED BY AMENDMENT

For:	No. Filed	No. Extra	Rate	Fee
Basic Fee				$690.00
Total Claims:	19	0 x	$18.00	$ 00.00
Indep. Claims:	2	0 x	$78.00	$ 0.00
Total Filing Fee				$ 690.00

The Commissioner is hereby authorized to charge any fees which may be required by the paper and any additional fees during the entire pendency of the application to Account No. 50-0281. A preliminary amendment is enclosed.

The power of attorney appearing in the original papers in the prior application is to Thomas E. McDonnell, Reg. No. 26,950 and Ralph T. Webb, Reg. No. 33,047. The power of attorney for prosecuting this divisional application is Barry A. Edelberg, Reg No. 31,012 and Ralph T. Webb. The prior application is **not** being abandoned.

Docket No.: N.C. 82,502 PATENT APPLICATION
Inventor's Name: Donald U. Gubser and M. Ashraf Imam

Please address all future communications to:

Ralph T. Webb
Associate Counsel (Patents)
Code 1008.2
Naval Research Laboratory
4555 Overlook Avenue, S.W.
Washington, D.C. 20375-5320

Please amend the specification by inserting a new first paragraph: --This is a division of copending US Application Serial No. 08/877,880, filed on June 18, 1997.--

I hereby verify that the attached papers are a true copy of prior parent application Serial No. 08/877,880 as originally filed on Jun 18, 1997.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Prepared by:
Ralph T. Webb
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BARRY A. EDELBERG
Reg. No.31,012

PATENT APPLICATION
Docket No.: N.C. 82,502

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Gubser et al
Divisional of Serial No.08/877,880
Parent Filed: June 18, 1997
For: HIGH TEMPERATURE SUPERCONDUCTING CERAMIC OXIDE COMPOSITE WITH RETICULATED METAL FOAM

Examiner: Not yet assigned.
Group Art Unit: Not yet assigned

July 6, 2000

PRELIMINARY AMENDMENT

Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

Preliminary to examination, kindly amend the above-identified application as follows:

IN THE CLAIMS:

Please cancel Claims 1 - 17.

Please amend Claims 18 and 19 as follows:

18. (amended) A high temperature superconducting composite made by a process comprising the steps of

providing a reticulated foam structure comprising a metal selected from the group consisting of silver, silver alloy, gold and gold alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

filling the continuous open cells of the reticulated foam structure with a high temperature superconducting ceramic oxide or precursor,

compacting the filled structure, and

heating the compacted structure to melt and/or texture the high temperature superconducting ceramic oxide or precursor to form a continuous region of high temperature superconducting ceramic oxide throughout the compacted structure[.], wherein the metal is selected to have a higher melting temperature than the melt/texture temperature of the superconducting ceramic oxide or precursor.

19. (amended) A high temperature superconducting composite conductor made by a process comprising the steps of

providing a reticulated foam structure made of a metal selected from the group consisting of silver, silver alloy, gold and gold alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

enclosing the reticulated foam structure in a sheath,

filling the continuous open cells of the enclosed reticulated foam structure with a superconducting ceramic oxide or precursor,

compacting the sheath, thereby compacting the enclosed filled reticulated foam structure, and

heating the compacted sheath to melt and/or texture the compacted superconducting ceramic oxide or precursor to form a composite superconducting conductor having a continuous region of superconducting ceramic oxide throughout the enclosed, compressed reticulated foam structure[.],

wherein the metal is selected to have a higher melting temperature than the melt/texture temperature of the superconducting ceramic oxide or precursor.

Please add the following new claims 20 - 29

--20. A high temperature superconducting composite made by a process comprising the steps of:

providing a reticulated foam structure made up of a silver alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

filling the continuous open cells of the reticulated foam structure with a high temperature superconducting ceramic oxide or precursor,

compacting the filled structure, and

heating the compacted structure to melt and/or texture the high temperature superconducting ceramic oxide or precursor to form a continuous region of high temperature superconducting ceramic oxide throughout the compacted structure, wherein the compacted structure is heated to a temperature that is less than the melting temperature of the silver alloy.

21. A composite superconducting conductor made by a process comprising the steps of:

providing a reticulated foam structure made of a silver alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

enclosing the reticulated foam structure in a sheath,

filling the continuous open cells of the enclosed reticulated foam structure with a superconducting ceramic oxide or precursor,

compacting the sheath, thereby compacting the enclosed filled reticulated foam structure, and

heating the compacted sheath to melt and/or texture the compacted superconducting ceramic oxide or precursor, wherein the compacted structure is heated to a temperature that is less than the melting temperature of the silver alloy, to form a composite superconducting conductor having a continuous region of superconducting ceramic oxide throughout the enclosed, compacted reticulated foam structure.

22. The composite superconducting conductor of claim 21, wherein the silver alloy is a silver-palladium alloy.

23. The composite superconducting conductor of claim 22, wherein the silver-palladium alloy comprises at least about 80 % silver by weight.

24. The composite superconducting conductor of claim 22, wherein the silver-palladium alloy comprises at least about 90 % silver by weight.

25. A method of making a high temperature superconducting composite comprising the steps of:

providing a reticulated foam structure made up of a silver alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

filling the continuous open cells of the reticulated foam structure with a high temperature superconducting ceramic oxide or precursor,

compacting the filled structure, and

heating the compacted structure to melt and/or texture the high temperature superconducting ceramic oxide or precursor to form a continuous region of high temperature superconducting ceramic oxide throughout the compacted structure, wherein the compacted structure is heated to a temperature that is less than the melting temperature of the silver alloy.

26. A method of making a composite superconducting conductor comprising the steps of:

providing a reticulated foam structure made of a silver alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

enclosing the reticulated foam structure in a sheath,

filling the continuous open cells of the enclosed reticulated foam structure with a superconducting ceramic oxide or precursor,

compacting the sheath, thereby compacting the enclosed filled reticulated foam structure,

heating the compacted sheath to melt and/or texture the compacted superconducting ceramic oxide or precursor, wherein the compacted structure is heated to a temperature that is less than the melting temperature of the silver alloy, to form a composite superconducting conductor having a

continuous region of superconducting ceramic oxide throughout the enclosed, compacted reticulated foam structure.

27. The method of claim 26, wherein the silver alloy is a silver-palladium alloy.

28. The method of claim 27, wherein the silver-palladium alloy comprises at least about 80 % silver by weight.

29. The method of claim 27, wherein the silver-palladium alloy comprises at least about 90 % silver by weight.--

REMARKS

An amendment adding a cross-reference to the earlier filed, copending parent application, U.S. Serial No. 08/877,880, was included in the Request to File a Divisional Application Under 37 CFR 1.53(b)(1), filed herewith.

The present amendment cancels Claims 1 - 17, which are elected claims in the copending parent application. Claims 18 -19 and new claims 20 - 29 remain in the application for examination.

Kindly charge any additional fees due, or credit overpayment of fees, to Deposit Account No. 50-0281.

Respectfully submitted,

Barry A. Edelberg
Reg. No. 31,012

Prepared by:
Ralph T. Webb
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(202) 404-1554

Inventor's Name: Donald U. Gubser and M. Ashraf Imam

HIGH TEMPERATURE SUPERCONDUCTING CERAMIC OXIDE COMPOSITE WITH RETICULATED METAL FOAM

Background of the Invention

1. Field of the Invention

The invention relates to high temperature superconducting composite materials, and more particularly to a high temperature superconducting composite material made by filling the open cells of a silver, silver alloy, gold or gold alloy foam with a high temperature superconducting ceramic oxide.

2. Description of the Related Art.

Superconducting ceramic oxides with critical temperatures that exceed the temperature of liquid nitrogen have been developed in recent years. However, the full potential of these materials for transporting power or generating magnetic fields has not been realized because the ceramic oxides are hard, brittle and difficult to form in proper geometries (wires, rods or tapes) with the requisite composition and structural orientation.

Superconducting rods, wires or tapes may be fabricated by packing the ceramic oxide powder into a metal tube and then drawing the tube into a wire or rod or flattening it into a tape. Methods of making single strand conductors are disclosed in U.S. Patent No. 4,980,964 to Boeke and U.S. Patent No. 5,206,211 to Meyer. To create a multifilamentary conductor for use in

magnets, the wire can be rebundled and then redrawn or rolled into a tape. A method of fabricating superconducting ceramic tape is to coat the ceramic onto one or both sides of a metal tape. Various other geometric configurations for superconducting wire with multiple filaments are disclosed in U.S. Patent No. 4,929,596 to Meyer et al, U. S. Patent No. 4,849,288 to Schmaderer et al, U.S. Patent No. 5,374,612 to Ito et al, U.S. Patent No. 5,017,553 to Whitlow et al and U.S. Patent No. 5,347,085 to Kikuchi et al. Conductors as described above are limited in their current carrying capacity because individual superconducting filaments are subject to material inhomogeneities.

Other approaches to reinforcing superconducting ceramics, making them stronger and easier to fabricate, are to disperse metal particles throughout a superconducting matrix or to disperse superconducting ceramic particles throughout a metal matrix. U.S. Patent No. 5,082,826 to Ferrando discloses a superconducting ceramic powder in which powder particles are coated with silver. U.S. Patent No. 4,983,574 to Meyer describes a conductor having particles of ceramic sintered high-temperature superconductor embedded in a metal matrix. U.S. Patent No. 5,306,704 to Gleixner et al discloses a method of dispersing a metal homogeneously throughout a superconducting material by blending the metal and a superconducting oxide, melting the blend and blowing the blend to form glasseous filaments. Superconducting materials as described above contain either discontinuous ceramic oxide particles or discontinuous metal particles. The dispersion of metal throughout a ceramic matrix or the dispersion of ceramic throughout a metal matrix provides improved strength and flexibility, but results in poorer superconducting properties and thermal stability. U.S. Patent No. 5,470,821 to Wong et al describes a bulk composite

superconducting material made by combining ceramic oxide and metallic particulates. The composite is compressed so that the metallic material fills the interstices between the ceramic oxide particles.

Summary of the Invention

It is an object of the invention to provide a high temperature superconducting ceramic oxide composite with a high current carrying capacity.

It is a further object of the invention to provide a high temperature superconducting ceramic oxide composite that is mechanically strong.

It is a further object of the invention to provide a high temperature superconducting ceramic oxide composite that has a large interface area with silver, silver alloy, gold or gold alloy uniformly spaced throughout the composite.

It is a further object of the invention to provide a high temperature superconducting ceramic oxide composite that allows for rapid and uniform oxygenation of the superconducting ceramic oxide.

It is a further object of the invention to provide a high temperature superconducting ceramic oxide composite that provides high thermal conductivity to minimize the development of hot spots during operation as a superconductor.

It is a further object of the invention to provide a high temperature superconducting ceramic oxide composite that is easy and inexpensive to fabricate.

These and other objects are accomplished by a method of making a high temperature

superconducting composite comprising the steps of providing a reticulated foam structure made of a metal selected from the group consisting of silver, silver alloy, gold and gold alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells, filling the continuous open cells of the reticulated foam structure with a high temperature superconducting ceramic oxide or precursor, compacting the filled structure, and heating the compacted structure to melt and/or texture the high temperature superconducting ceramic oxide or precursor to form a continuous region of high temperature superconducting ceramic oxide throughout the compacted reticulated foam structure. Making a composite by the method outlined above results in a composite that is mechanically strong, and has a large interface area between the superconducting ceramic oxide and the metal, which allows a uniform current flow and a high current density. Since oxygen diffuses more rapidly through the metals listed above than it does through a ceramic oxide, the large interface area allows for more rapid and more homogeneous oxygenation. Because the metals are more thermally conductive than ceramic oxide, the thermal stability of the superconducting ceramic oxide is enhanced.

Brief Description of the Drawings

Figure 1 is an diagrammatic, perspective view partly in section of a superconducting wire of the present invention.

Figure 2 is a diagrammatic, perspective view partly in section of a second embodiment of a superconducting wire of the present invention.

Figure 3 is a plot of voltage, V vs. current, I, of a high temperature superconducting rod with a cross-sectional area of 0.0616 cm^2.

Detailed Description of the Preferred Embodiments

The present invention is a method of making a high temperature superconducting ceramic oxide composite by filling the open cells of a reticulated silver, silver alloy, gold or gold alloy foam structure with a superconducting ceramic oxide or precursor and then compacting and heating the structure to make a composite that has a continuous region of high temperature superconducting ceramic oxide interlaced throughout the compacted reticulated metal foam.

The reticulated foam structure can be any structure that has a plurality of continuous cross-linked ligaments or filaments that define a plurality of continuously connected open cells that can be filled with a superconducting ceramic oxide. As used herein, the term "open cells" refers to the open spaces between or among cross-linked ligaments or filaments. The criterion for selecting a preferred reticulated foam structure for the invention is to provide a structure that, when the open spaces are filled with a superconducting material, will have a large interface area between the structural material (the metal foam) and the superconducting material (the ceramic oxide) while providing both continuous ligaments of the structural material and a continuous region of superconducting material. While the invention is not limited to these embodiments, examples of reticulated foam structures having suitable geometry for the practice of the invention are described in U.S. Patent No. 3,616,841 to Walz and U.S. Patent No. 3,946,039 to Walz, and U.S. Patent No. 4,235,277 to Aizawa, the disclosures of which are hereby incorporated by reference. Also, reticulated foam materials are fabricated by Energy Research and Generation, Inc. of Oakland, Ca. under the trademark Duocel ®.

Reticulated foam structures are typically defined in terms of the relative density of the

foam structure as compared to the density of the bulk material of the same composition. Preferably, the reticulated foam structure of the present invention (before filling with the superconducting ceramic oxide) will have a relative density of from about 5 % to about 55 % of that of the bulk material. Most preferably, the reticulated foam structure will have a relative density of from about 10 % to about 30 % of that of the bulk material. Another typical way of defining the geometry of a foam structure is in terms of pores per inch. Preferably, the reticulated foam structure of the present invention will have from about 5 to about 80 pores per inch.

The reticulated foam structure is preferably made of silver, silver alloy, gold or gold alloy. Because the preparation of the superconducting composite requires a heating step to melt and/or texture the superconducting ceramic or precursor at a temperature, which, for particular ceramic oxides, may be above the melting temperature of pure silver, it is preferred that a silver alloy selected to have a melting temperature above the melting and/or texturing temperature of the particular ceramic oxide be used in the practice of the invention. Preferably, the silver alloy is a silver-palladium alloy that is at least 80 % silver, more preferably at least 90 % silver by weight.

Any high temperature superconducting ceramic oxide may be used in the practice of the invention. A high temperature superconducting ceramic oxide is typically defined as a ceramic oxide superconductor that has an onset or critical temperature (T_c) above the temperature of liquid nitrogen. Preferably, the high temperature superconducting ceramic oxide is selected from the group consisting of bismuth - based superconducting ceramic oxides, thallium - based superconducting ceramic oxides, yttrium - based superconducting ceramic oxides, and mercury -

based superconducting ceramic oxides. Most preferably, the high temperature superconducting ceramic oxide is selected from the group consisting of $Bi_2Sr_2Ca_1Cu_2O_y$ (BSCCO), $Bi_2Sr_2Ca_2Cu_3O_y$, $Y_1Ba_2Cu_3O_y$ (YBCO), $Tl_2Ba_2Ca_2Cu_3O_y$, $Tl_1Ba_2Ca_2Cu_3O_y$, $Hg_1Ba_2Ca_2Cu_3O_y$ and $Hg_1Ba_2Ca_1Cu_2O_y$. In each of the above formulas, y represents the relative oxygen content in the range appropriate for the particular superconducting ceramic oxide. Alternatively, precursors of superconducting ceramic oxides can be used. Precursors are mixtures of oxides that collectively have the same nominal composition as a superconducting ceramic oxide and which form a superconducting ceramic oxide upon heating. The superconducting ceramic oxide or precursor used in the method of the invention is initially in the form of a powder or slurry so that it can fill the open spaces in the reticulated foam structure. The superconducting ceramic oxide or precursor is formed into a powder or slurry by any conventional means.

The high temperature superconducting ceramic oxide composite of the present invention is formed by filling the open spaces of the reticulated foam structure with a superconducting ceramic oxide or precursor, compacting the filled structure and then heating the compacted structure to melt and/or texture the ceramic oxide or precursor. These steps can be conducted in any manner.

The temperature for the heating step depends on the melting and/or texturing temperature of the particular ceramic oxide. When a superconducting ceramic oxide is used in the method of the invention, the heating step serves to solidify and texture the superconducting ceramic oxide to form a continuous region of the superconducting ceramic oxide throughout the structure and to optimize the superconducting properties. Texturing is enhanced at the metal/superconductor

interface; therefore, the extensive interfaces provided by this invention will promote texturing. Texturing occurs during the solidification process if the ceramic oxide material is melted. When a precursor is used, the heating step also serves to effect the conversion of the precursor to the superconducting ceramic oxide and then to solidify and texture the newly formed superconducting ceramic oxide. Temperatures used in the melting and texturing of superconducting ceramic oxides are typically in the range of 800° C to 1100° C.

The reticulated foam structure should be enclosed in a sheath before the step of filling the continuous open cells of the reticulated foam structure with the high temperature superconducting ceramic oxide or precursor to avoid the leakage and spillage of the material during the filling and compacting steps. The sheath may be of any form and made of any material suitable for enclosing the reticulated foam structure to prevent leakage and spillage and for being compacted. Preferably, the sheath is a tubular material having the same chemical composition as the reticulated foam structure.

The method of the present invention is particularly well-suited for forming superconducting composite conductors, particularly wires, rods, or tapes. To form a superconducting wire, rod or tape, the reticulated foam structure is placed inside a sheath, which is preferably a hollow cylinder such as a tube or pipe of a suitable size to fit around the reticulated foam structure. Preferably, the reticulated foam structure is in the shape of a cylinder that has an outer diameter that is approximately equal to the inner diameter of the sheath so that the reticulated foam structure fits snugly into the sheath. The sheath should be closed on one end to prevent leakage of the superconducting ceramic oxide or precursor during the filling step and

should have an open end through which the reticulated foam structure is filled with the superconducting ceramic oxide or precursor. After the open cells of the reticulated foam structure are filled, the sheath is closed or sealed. The sheath may then be formed into a rod or wire by reducing the outer diameter of the sheath by any conventional means such as by drawing, swaging or extruding. The sheath may be formed into a tape by any conventional means of flattening. Forming the sheath into a wire, rod or tape also serves to compact the enclosed reticulated foam structure and the superconducting ceramic oxide or precursor contained therein. The wire, rod or tape is then heated to texture the superconducting ceramic oxide or, when ceramic oxide precursors are used, to synthesize, melt and texture the corresponding superconducting ceramic oxide so that a continuous region of high temperature superconducting ceramic oxide is formed throughout the compacted reticulated foam structure. Shown diagrammatically in Figure 1 is a cross section of a superconducting wire made according to the process of the present invention, including the compacted reticulated foam structure 1, the high temperature superconducting ceramic oxide 2, and the surrounding sheath 3.

In instances where it is desired to minimize thermal conduction along the composite, the sheath may be removed by any conventional means. Shown diagrammatically in Figure 2 is a cross section of a superconducting wire wherein the sheath has been removed, including the compacted reticulated foam structure 4 and the high temperature superconducting ceramic oxide 5.

The preparation of a superconducting ceramic oxide composite may also include a step of oxygenating the superconducting ceramic oxide to improve its superconducting properties.

The superconducting ceramic oxide composite or conductor of the present invention can

be used in any application where transporting electricity or generating a magnetic field with minimal power loss is desired. The composite may be cooled below the temperature at which the material becomes superconducting by any conventional means, including by immersing it in liquid nitrogen, neon or helium, by convection cooling with a gas or by conductive cooling by attaching the composite to a cryocooler.

Having described the invention, the following examples are given to illustrate specific applications of the invention, including the best mode now known to perform the invention. The specific examples are not intended to limit the scope of the invention described in this application.

Examples

Example 1

Reticulated foam material of a silver-palladium alloy having about 90 % silver and a pore size of 10 pores per inch was obtained from Energy Research and Generation, Inc., Oakland Ca. The material was cut into the shape of a cylinder having a diameter of 1.5 cm and placed tightly inside a copper tube that was sealed on one end. (Copper tubing was chosen only because of its low cost and availability for quickly constructing an experimental prototype; the preferred material for the practice of the invention is a silver-palladium alloy as described in Example 2 below.) The tube was then filled with YBCO powder so that the YBCO powder filled the open cells of the reticulated foam material. The open end of the tube was capped shut and the tube was

then swaged to form a wire. The copper sheath was then dissolved away by immersing the wire in nitric acid. The wire was then melt-textured by slowly passing it through a furnace with a peak temperature of 1050° C.

Fig. 3 shows a plot of voltage, V, vs. current, I, for a wire made as described above with a cross-sectional area of 0.0616 cm^2. The measurements were made at 77°K with a zero magnetic field. The plot shows a critical current, I_c of 21.5A., which gives a current density, J_c of 349 A/cm^2.

Example 2

Reticulated foam material of a silver-palladium alloy having about 90 % silver and a pore size of 10 pores per inch is cut into the shape of a cylinder having a diameter of 1.5 cm and placed tightly inside a tube of silver-palladium alloy of the same composition. The tube is sealed on one end. The tube is then filled with YBCO powder. The open end of the tube is sealed. The tube is then swaged to form a wire. The wire is then melt-textured by slowly passing it through a furnace with a peak temperature of 1050° C.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

Claims

What is claimed is:

1. A method of making a high temperature superconducting composite comprising the steps of

providing a reticulated foam structure comprising a metal selected from the group consisting of silver, silver alloy, gold and gold alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

filling the continuous open cells of the reticulated foam structure with a high temperature superconducting ceramic oxide or precursor,

compacting the filled structure, and

heating the compacted structure to melt and/or texture the high temperature superconducting ceramic oxide or precursor to form a continuous region of high temperature superconducting ceramic oxide throughout the compacted structure.

2. A method of making a composite superconducting conductor comprising the steps of

providing a reticulated foam structure made of a metal selected from the group consisting of silver, silver alloy, gold and gold alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

enclosing the reticulated foam structure in a sheath,

filling the continuous open cells of the enclosed reticulated foam structure with a superconducting ceramic oxide or precursor,

compacting the sheath, thereby compacting the enclosed filled reticulated foam structure,

heating the compacted sheath to melt and/or texture the compacted superconducting ceramic oxide or precursor to form a composite superconducting conductor having a continuous region of superconducting ceramic oxide throughout the enclosed, compacted reticulated foam structure.

3. The method of claim 2, wherein the step of compacting the sheath involves forming the sheath into a wire.

4. The method of claim 2, wherein the step of compacting the sheath involves forming the sheath into a rod.

5. The method of claim 2, wherein the step of compacting the sheath involves forming the sheath into a tape.

6. The method of claim 2, wherein the reticulated foam structure is a silver-palladium alloy.

7. The method of claim 6, wherein the silver-palladium alloy comprises at least about 80 % silver by weight.

8. The method of claim 6, wherein the silver-palladium alloy comprises at least about 90 % silver by weight.

9. The method of claim 2, wherein the reticulated foam structure has a relative density of from about 5 % to about 55 % of that of bulk non-superconducting metal of the same

composition.

10. The method of claim 2, wherein the reticulated foam structure has a relative density of from about 10 % to about 30 % of that of bulk metal of the same composition.

11. The method of claim 2, wherein the reticulated foam structure is characterized as having from about 5 to about 80 pores per inch.

12. The method of claim 2, wherein the high temperature superconducting ceramic oxide or precursor before the heating step is in the form of a powder.

13. The method of claim 2, wherein the high temperature superconducting ceramic oxide or precursor before the heating step is in the form of a slurry.

14. The method of claim 2, wherein the high temperature superconducting ceramic oxide is selected from the group consisting of bismuth - based superconducting ceramics, thallium - based superconducting ceramics, yttrium - based superconducting ceramics, and mercury - based superconducting ceramics.

15. The method of claim 2, wherein the high temperature superconducting ceramic oxide is selected from the group consisting of $Bi_2Sr_2Ca_1Cu_2O_y$, $Bi_2Sr_2Ca_2Cu_3O_y$, $Y_1Ba_2Cu_3O_y$, $Tl_2Ba_2Ca_2Cu_3O_y$, $Tl_1Ba_2Ca_2Cu_3O_y$, $Hg_1Ba_2Ca_2Cu_3O_y$ and $Hg_1Ba_2Ca_1Cu_2O_y$.

16. The method of claim 2, wherein the reticulated foam structure has a cylindrical shape, wherein the sheath is a tube having a sealed end, and wherein the outer diameter of the reticulated foam structure is approximately equal to the inner diameter of the tube.

17. The method of claim 2, wherein the sheath is made of a metal having the same composition as that of the reticulated foam structure.

18. A high temperature superconducting composite made by a process comprising the steps of

providing a reticulated foam structure comprising a metal selected from the group consisting of silver, silver alloy, gold and gold alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

filling the continuous open cells of the reticulated foam structure with a high temperature superconducting ceramic oxide or precursor.

compacting the filled structure, and

heating the compacted structure to melt and/or texture the high temperature superconducting ceramic oxide or precursor to form a continuous region of high temperature superconducting ceramic oxide throughout the compacted structure.

19. A high temperature superconducting composite conductor made by a process comprising the steps of

providing a reticulated foam structure made of a metal selected from the group consisting of silver, silver alloy, gold and gold alloy, the reticulated foam structure having continuous ligaments defining a plurality of continuous open cells,

enclosing the reticulated foam structure in a sheath,

filling the continuous open cells of the enclosed reticulated foam structure with a superconducting ceramic oxide or precursor,

compacting the sheath, thereby compacting the enclosed filled reticulated foam structure,

heating the compacted sheath to melt and/or texture the compacted superconducting

ceramic oxide or precursor to form a composite superconducting conductor having a continuous region of superconducting ceramic oxide throughout the enclosed, compressed reticulated foam structure.

Docket No.: N.C. 78,130

PATENT APPLICATION

Inventor's Name: Donald U. Gubser and M. Ashraf Imam

ABSTRACT

A high temperature superconducting composite rod, wire or tape is formed by filling the open cells of a reticulated foam structure made of silver, silver alloy, gold or gold alloy with a superconducting ceramic oxide or precursor, compacting the filled structure and forming it into a rod, wire or tape and heating it to melt and/or texture the superconducting ceramic oxide. The resulting composite has continuous ligaments of metal throughout a continuous region of superconducting ceramic oxide.

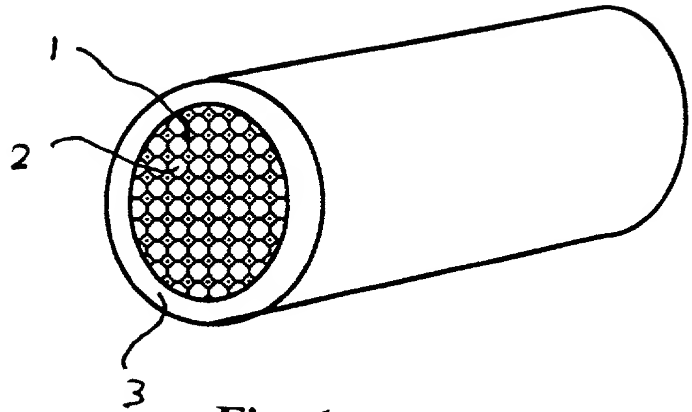

Fig. 1

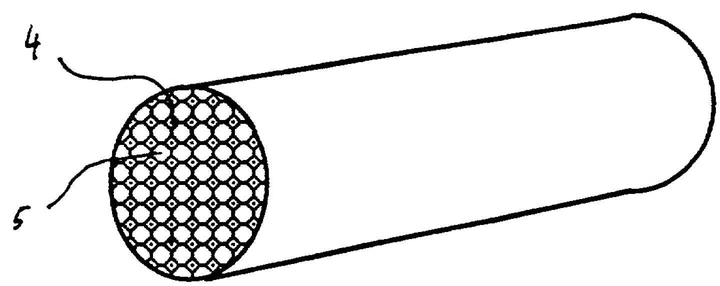

Fig. 2

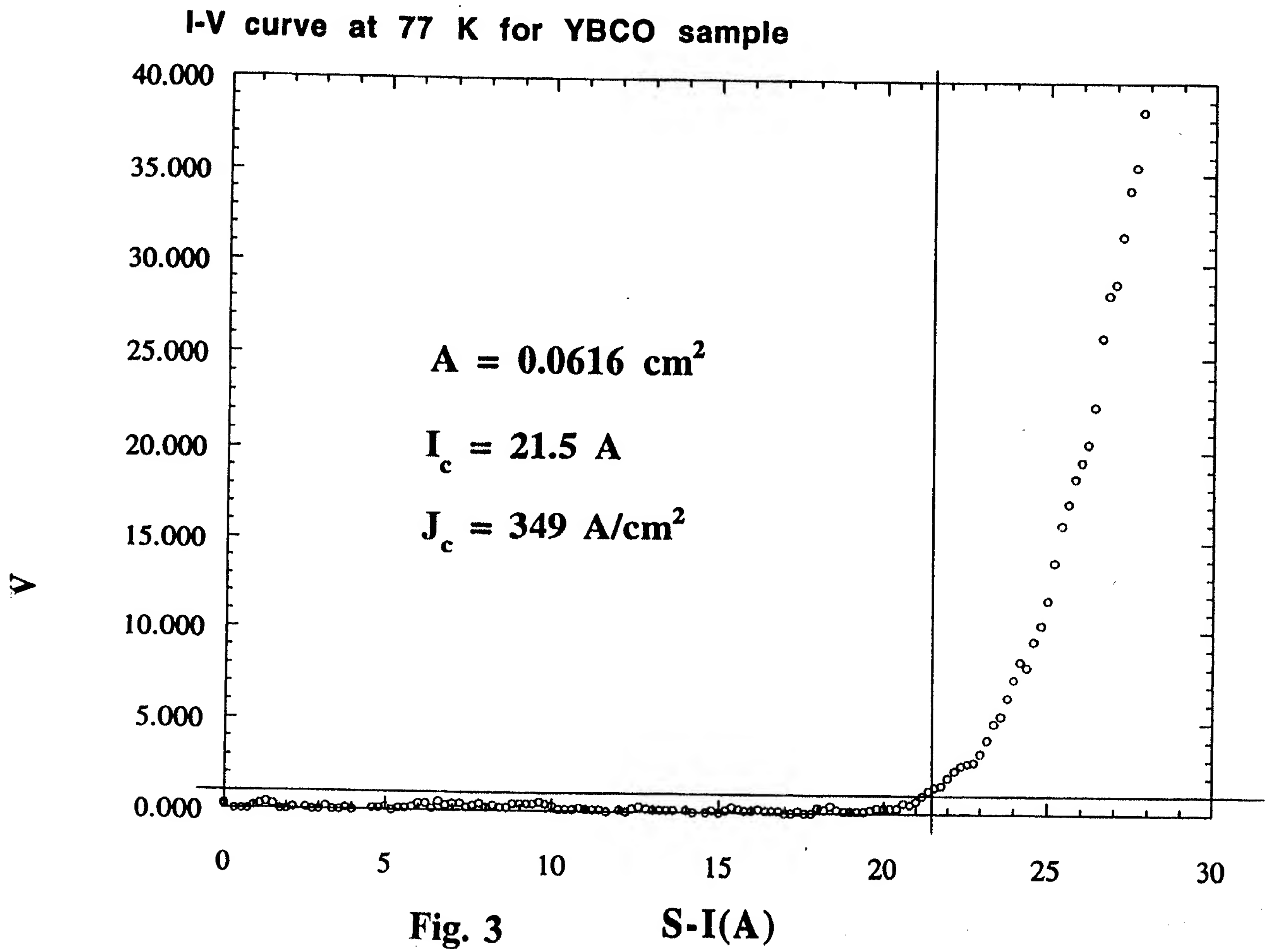

Fig. 3

09612979 .071000

Navy Case No. 78,130

Declaration and Power of Attorney For Patent Application

As a below named inventor, We hereby declare that:
Our residences, post office address and citizenship are as stated below next to my name. We believe we are the original, first, and joint inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled: HIGH TEMPERATURE SUPERCONDUCTING CERAMIC OXIDE COMPOSITE WITH RETICULATED METAL FOAM, the specification of which:

(check one) [X] is attached hereto. [ ] was filed on ______________ as
Application Serial No. _____
and was amended on __________________.

We hereby state that we have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

We acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

We hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign applications for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Applications			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

We hereby claim the benefit under Title 35, United States Code, §120 of any United States applications listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of title 35, United States Code, §112, we acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

POWER OF ATTORNEY: As a named inventor, we hereby appoint the following attorneys/and/or agent/s/ to prosecute this application and transact all business in the Patent and Trademark Office connected therewith, and hereby certify that the Government of the United States has the irrevocable right to prosecute this application:

Thomas E. McDonnell, Reg. No. 26,950, and Ralph T. Webb, Reg. No. 33047

SEND CORRESPONDENCE TO:
Associate Counsel (Patents), Code 3008.2
Naval Research Laboratory
Washington, D.C. 20375-5000

DIRECT TELEPHONE CALLS TO:
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(202)-404-1554

We hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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